National Aeronautics and Space Administration

alternative energy

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NASA: A Legacy of Energy and Power Advances for Space Exploration

Many of the technologies developed for space have rich potential in a future that emphasizes sustainable alternative energy.

Energy and power have always been extremely important elements of NASA's mission, and many of NASA's investments in energy—especially in the early years—have given rise to commercial products, including solar photovoltaics, batteries, and fuel cells.

Solar Photovoltaics: Energy From the Sun for Long-Duration Missions

International Space Station.

Most spacecraft use solar photovoltaics that convert light energy from the Sun directly into electricity. The solar cells used by the first solar-powered satellite were only 5 percent efficient, but they enabled the satellite to last 7 years, instead of the 20 days that battery power would have provided. After 50 years, solar cells are still being used in space. They are the primary power source for the International Space Station, the largest solar-powered space vehicle ever built. Efficiency has increased significantly. Currently available solar cells are 19 percent efficient, and laboratory cells have demonstrated over 30 percent efficiency.

Batteries: Reliable and Cyclic Energy Storage

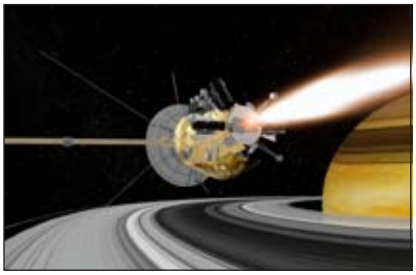
Mars Exploration Rover.

Batteries, which store energy for use on demand, have been used in space since Explorer 1—the first U.S. satellite—was launched in 1958. Batteries have improved dramatically and are now lighter, smaller, and last longer while providing more power than ever before. Batteries in space currently work hand-in-hand with solar photovoltaics, storing energy for use when sunlight is not available. The chemistry of space batteries has changed over time, with lithium-ion batteries currently being used on the Mars Exploration Rovers.

Fuel Cells: High Power for Crewed Missions

NASA fuel cell development work dates back to the Gemini program. Today alkaline fuel cells provide power on the space shuttle, and an oxygen/hydrogen fuel cell provides potable water during shuttle missions.

Radioisotope Power Systems: Long-Life Power Independent of the Sun



Radioisotope power systems generate electrical power by converting the heat released from the nuclear decay of a radioactive isotope (plutonium-238) into electricity. These systems have enabled missions beyond the orbit of Mars since 1961.

Cassini mission to Saturn.

NASA: Continuing to Pioneer Sustainable Alternative Energy

NASA continues to pioneer this critically important area through its own research and development, as well as that of other agencies and industry, in new arenas such as dynamic power conversion, advanced batteries, and alternative fuels.

NASA Glenn Research Center: A Legacy of Energy and Power Technology Development and Demonstration

NASA Glenn, formerly the NASA Lewis Research Center, has not only played a critical role in the energy and power programs within NASA, but has a legacy tied directly to the energy technology efforts sponsored by the Environmental Research and Development Administration (ERDA, the predecessor to the U.S. Department of Energy) during the energy crisis of the 1970s.

Automotive Technology: Cleaner Burning and Electric Engines

NASA Glenn's expertise in energy conversion for NASA led to the staffing of an Automotive Systems Office funded by the Environmental Protection Agency to develop gas turbines as cleaner-burning automobile engines. Later, Stirling engine and electric-powered cars were developed and demonstrated.

Nickel-zinc battery development for electric vehicles.

Wind Turbine Technology: Experimental Designs Demonstrated

Clusters of 2.5-MW wind turbines were demonstrated in the states of Washington and California.

Between 1974 and 1981, NASA Glenn led the U.S. Wind Energy Program for large horizontal-axis wind turbines, which are the predominant system in use today. Thirteen experimental wind turbines, of four major designs, were operated in a variety of settings.

Photovoltaic Technology: Power for Developing Countries

From 1975 to 1985, NASA Glenn designed, fabricated, and installed 57 photovoltaic systems in 27 developing countries. These projects demonstrated alternative means of generating electrical energy without resorting to diesel-powered generators. In 1978 NASA Glenn built the first solar-powered village for the Papago Tribe in Schuchuli, Arizona.

Fuel Cell Technology: Stand-Alone Power

The police station in Central Park provided power during the New York City Blackout of 2003.

The Department of Energy had a specific interest in the development of fuel cell systems for stand-alone power. NASA Glenn led the development of phosphoric acid fuel cells and participated in other technology areas, such as molten carbonate and solid oxide. The phosphoric acid fuel cell project led to the successful development of commercially available stand-alone power units ranging from 50 to 85 percent efficiency and demonstrating 99.5 percent reliability. Units of over 250 kW were installed worldwide.

NASA Glenn Research Center: Renewable Energy Activities Today

Taking advantage of NASA's legacy of reducing energy requirements for space exploration and striving to be a good citizen, NASA Glenn continues to demonstrate a variety of renewable energy activities while augmenting its own energy needs.

Plugging Into Solar Energy: Clean Electricity

Photovoltaic system in NASA Glenn's West Area.

In 2006 Glenn engineers designed, developed, and installed a 2-kW photovoltaic (PV) system that captures energy from the Sun. The system was plugged into Glenn's utility distribution grid and synchronized with the utility system to provide electricity for a Glenn facility and to sell any excess power to the utility system. The system provides approximately 10 W of alternating-current power per square foot of area and has generated more than 5500 kWh since its activation in July 2006. Encouraged by this success, Glenn added a 12-kW PV system to the roof of its Visitor Center. Since activation in 2008, the Visitor Center system has generated more than 6000 kWh. Not only are these systems providing clean, safe, reliable, efficient, and economical solar power for Glenn, but Glenn researchers are gaining experience and test data from PV systems similar to those used for space exploration and are studying how solar energy varies in Cleveland, Ohio.

Hydrogen Fuel for a Green Bus: Thanks to the Sun and the Wind

Concept for the fuel-cell bus and hydrogen fuel station.

A team led by Glenn is designing a demonstration fuel station that will use wind and solar energy to produce hydrogen fuel. The hydrogen, will, in turn, be used to power a rapid transit bus equipped with fuel cells. The station will be built at the Great Lakes Science Center in Downtown Cleveland and will use the science center's wind turbine and solar array to power an electrolyzer to split water into hydrogen and oxygen. The group plans to have the system ready by May 2010, when a full-size prototype fuel cell bus should be available from United Technologies. The bus's tailpipe will emit only water and water vapor.

Alternative Fuels and Biofuels: Power for Future Jet Aircraft

Halophytes growing in Glenn's GreenLab.

Glenn has partnered with Boeing, Pratt & Whitney, and the Air Force Research Laboratory to assess the performance, emissions, and thermal stability of Fischer-Tropsch fuels, blends, and biofuels for commercial aircraft. The Fischer-Tropsch process converts coal, natural gas, and other hydrocarbon materials to liquid alternative fuels. The team has demonstrated that advanced aircraft can run on various blends, including pure alternative fuel, with no combustor or fuel compatibility problems and with gas and particle emissions significantly lower than for traditional jet fuel. As the team continues to investigate these fuels, it is beginning to study biofuels. Earth has limited land that is suitable for food agriculture: 97 percent of the Earths' water is seawater, and 43 percent of the Earth's land is arid. Glenn's new Biofuels Research Laboratory and GreenLab are being used to study the practicality of creating biofuels from seawater algae and halophytes (salt-tolerant plants that can thrive with seawater or brackish water irrigation in arid or coastal regions unsuitable for growing food crops). Researchers are developing photobioreactor algae systems and are growing halophytes in salinities similar to those of coastal regions around the world. They also plan to collaborate with aviation companies, other commercial companies, and other Government agencies, and to apply biofuels to aviation.

Green Buildings: A Smaller Carbon Footprint

The geothermal-solar power system employs heat exchanger coils below the surface of the ground.

Nearly three-fourths of carbon dioxide emissions and energy use in cities comes from commercial buildings. Glenn is committed to several different technologies to reduce its carbon footprint. For example, Glenn will incorporate a coupled solar power and advanced ground source heat pump system into five of its buildings, including the new gate house.

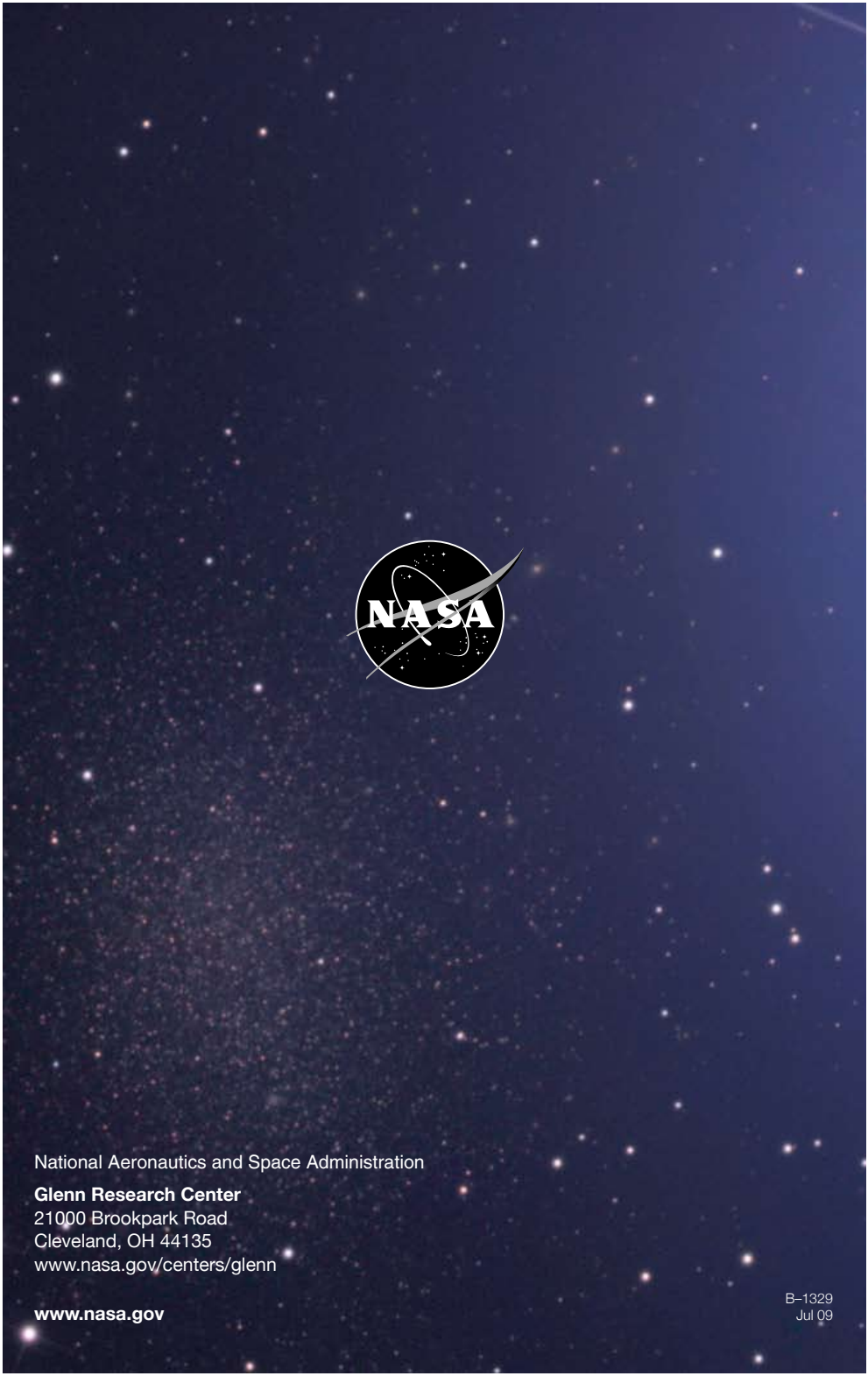
Green Buildings: A Smaller Carbon Footprint (continued)

Solar thermal power concentrator focusing the Sun's energy onto solar cells.

A solar thermal concentrator/photovoltaic system will be used at Glenn to produce electricity and to heat water. Two solar concentrators will focus the Sun's energy onto high-temperature solar cells to produce up to 1.5 kW of electricity. Water will be pumped behind the solar cells to cool them, and the heated water will be available for heating and other uses.

Guerin Management Center.

Glenn staff designed the new Guerin Management Center to have improved energy efficiency and indoor air quality and to use high-recycled-content-materials. It is Glenn's first building with an application for U.S. Green Building Council Leadership in Energy and Environmental Design (LEED) certification.



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